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UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

CV 09 5271

RUCKUS WIRELESS, INC., a Delaware corporation,

Plaintiff,

vs.

NETGEAR, INC., a Delaware corporation; and RAYSPAN CORPORATION, a Delaware corporation

Defendants.

CASE NO.

COMPLAINT FOR PATENT INFRINGEMENT

(U.S. Patent No. 7,525,486)

DEMAND FOR JURY TRIAL

Plaintiff Ruckus Wireless, Inc. ("RUCKUS") hereby alleges for its complaint against Defendants NETGEAR, Inc. ("NETGEAR") and Rayspan Corporation ("RAYSPAN") (each individually a "DEFENDANT" and collectively "DEFENDANTS") as follows:

JURISDICTION AND VENUE

1. The United States District Court for the Northern District of California (the "Court") has jurisdiction over this matter because it is an action for infringement arising under the United

States Patent Act (35 U.S.C. § 1 *et seq.*). Accordingly, the Court has jurisdiction pursuant to 28 U.S.C. §§ 1331 and 1338(a).

2. RUCKUS is informed and believes, and thereon alleges, that the DEFENDANTS are subject to personal jurisdiction in the Northern District of California (the "District") because the DEFENDANTS have caused tortious injury in this District by acts committed both inside and outside the District. The DEFENDANTS are further subject to personal jurisdiction in the District because the DEFENDANTS regularly solicit business in the District or derive substantial revenue from sales of goods—including goods infringing the patents-in-suit—in the District. Defendant NETGEAR, too, maintains its headquarters and principal place of business in the District. In any case, the DEFENDANTS have engaged in a persistent course of conduct in the District.

3. Venue for this action is proper in the District pursuant to 28 U.S.C. §§ 1391 and 1400 because a significant portion of the NETGEAR and RAYSPAN's infringing activities have occurred in the District. Defendant NETGEAR, too, maintains its headquarters and principal place of business in the District.

INTRA-DISTRICT ASSIGNMENT

4. For the purposes of Civil L.R. 3-2(c) and (d), this is an Intellectual Property action and may be assigned to any division of the District.

THE PARTIES

5. RUCKUS is a Delaware corporation that has its principal place of business in Sunnyvale, California. RUCKUS was formed in 2004 with the primary focus to make Wi-Fi sufficiently reliable to be used as a utility in the home, office, hot spots, and around the world.

6. RUCKUS is a pioneer in 'Smart Wi-Fi' technology. RUCKUS' Smart Wi-Fi technology delivers reliable signal quality over an extended range and is capable of automatically adapting to environmental changes in real-time. RUCKUS' patented Smart Wi-Fi technology solves a number of interference and signal range problems by focusing radio frequency (RF) energy and steering it around interference as it is experienced. As a result, RUCKUS Smart Wi-Fi

technology allows for a more predictable Wi-Fi signal that reaches farther and that may support delay sensitive applications such as streaming voice and multicast Internet Protocol (IP) video that heretofore had been difficult for Wi-Fi to reliably support.

7. RUCKUS' contributions to Wi-Fi have not gone unnoticed. RUCKUS was named a 2007 Technology Pioneer by the World Economic Forum. World Economic Forum Technology Pioneers are "innovators—companies that are developing and applying the most innovative and transformational technologies" and whose work "represents an enormous source of entrepreneurial talent." Technology Pioneers are "at the forefront of change."

8. RUCKUS and its Smart Wi-Fi technologies are the recipients of any number of other awards. These awards include the 2008 SPIFFY Award for Engineering Excellence for RUCKUS' innovative Smart Wi-Fi technology; the CableLabs 2008 Best New Product Idea Most Likely to Succeed; the 2007 NXTComm Eos Award for Home Networking; the 2007 CRN Emerging Vendor Award for delivering innovative and easy-to-use solutions that undercut those of industry giants; the 2007 ACE Award for Startup of the Year; the 2007 IPTV World Series Award for Best IPTV Transport Solution; and the CES Innovations 2007 Design and Engineering Award Honoree for unique and novel products that contribute to consumers' quality of life.

9. RUCKUS and its network of distributors and resellers ship Wi-Fi systems to customers around the world. RUCKUS has also procured financing from premier venture capital investors, consumer electronics companies, and broadband operators.

10. RUCKUS' Smart Wi-Fi products have received favorable reviews from a number of publications and reviewing entities including TechWorld; CWNP; Jones-Petrick and Associates; ZD Net; PC World; Network Computing; MSNBC; Hardware Zone; About.com; eWeek; Untangled Life; PC Pro; GadgetCentre.com; Network World; and EDN.

11. RUCKUS' technologies have been adopted by industry giants such as Deutsche Telekom, PCCW, Swisscom, SingTel, and Belgacom.

12. RUCKUS is informed and believes, and thereon alleges, that NETGEAR is a Delaware corporation that has its principal place of business at 350 East Plumeria Drive San Jose, California 95134-1911. NETGEAR purports to design, develop, and market branded

network products that address the specific needs of small and medium business and home users including wireless network products such as wireless routers.

13. RUCKUS is informed and believes, and thereon alleges, that RAYSPAN is a Delaware corporation that has its principal place of business at 11975 El Camino Real, Suite 301, San Diego, California. RAYSPAN claims to be the world's leading innovator of revolutionary meta-material air interface solutions for high performance wireless communication networks. RAYSPAN represents that its meta-material technology is integrated into a number of NETGEAR wireless products.

GENERAL ALLEGATIONS

The WPN824v1 and WPN824v2

14. On or about December 23, 2004, RUCKUS—then operating under the name of Video54 Technologies, Inc.—and NETGEAR entered into a Technology License Agreement. As a part of the Technology License Agreement, NETGEAR agreed to pay RUCKUS a royalty for each and every wireless router sold as a part of the WPN 824 product line and that incorporated certain RUCKUS proprietary technology. That proprietary technology was inclusive of a hardware design for an 802.11g/b wireless access point with a dynamically configurable antenna array for interference mitigation and performance optimization.

15. On January 5, 2005, at the 2005 Consumer Electronics Show in Los Vegas, Nevada, NETGEAR and RUCKUS announced the release of the RangeMax WPN 824v1 wireless router. The RangeMax WPN 824v1 was designed to boost wireless range in home networks and eliminate dead spots thereby improving support for bandwidth-intensive applications such as streaming audio and video, playing online games, and transferring large data files.

16. NETGEAR characterized the RangeMax WPN 824v1 as incorporating seven smart multiple-input-multiple-output (MIMO) antennas to deliver 127 unique antenna patterns that adapt 'on the fly' to the network environment by adjusting to RF interference, locations of a client, and physical barriers thereby resulting in extraordinary range and consistent high-speed data transfer performance.

17. According to Patrick Lo, the CEO and Chairman of NETGEAR, by partnering with RUCKUS, NETGEAR was "able to launch the revolutionary RangeMax technology which dynamically optimizes performance to vastly improve the speed and range of the wireless network, supporting the increasing performance demands of the home network for applications such as streaming multimedia content." RUCKUS' technology allowed NETGEAR to address "[o]ne of the pervasive issues encountered in the implementation of wireless networks": "sub-par network performance caused by elements such as RF interference and the physical structure in which the network is running."

18. On March 7, 2005, Vivek Pathela, NETGEAR Senior Director of Product Marketing for Consumer Products, characterized the RUCKUS powered RangeMax WPN824v1 wireless router as "the ideal solution for bandwidth-intensive consumer applications because it is uniquely able to dynamically optimize network connections by adapting on-the-fly to changes in the RF (Radio Frequency) environment such as interference introduced to the environment by turning on a microwave oven or using a 2.4GHz cordless phone." According to Pathela, the RangeMax WPN 824v1 utilizes "intelligent antenna overlay technology that enables [the] router to deliver superior coverage, speed and adaptability to changing wireless environments."

19. Following the release of the RangeMax WPN 824v1, NETGEAR requested the research and development support of RUCKUS to develop a second and more cost effective version of the RangeMax wireless router—the WPN 824v2. RUCKUS complied with NETGEAR's request and the WPN 824v2 may be purchased from NETGEAR and any number of NETGEAR resellers.

20. RUCKUS is informed and believes, and thereon alleges, that RUCKUS received a royalty on each of the RangeMax WPN 824v1 and WPN 824v2 routers sold by NETGEAR and/or its resellers in accordance with the December 2004 Technology License Agreement.

The WPN824v3

21. On October 31, 2007, the Federal Communications Commission's (FCC) Office of Engineering and Technology (OET) Laboratory Division released certain Certification request information for a new version of NETGEAR's RangeMax Wireless Router—the WPN824v3.

RUCKUS was not and has not been involved in the manufacture, design, or production of the WPN 824v3. Until the release of the aforementioned information by the FCC OET Laboratory Division, RUCKUS was unaware of the existence of the WPN 824v3. There is no contractual obligation or license by and between RUCKUS and NETGEAR (or any proxy thereof, including but not limited to RAYSPAN) that permits the incorporation of any RUCKUS intellectual property in any NETGEAR WPN product other than the 824v1 and 824v2.

22. NETGEAR characterizes the RangeMax WPN 824v3 as extending wireless network coverage up to ten times that of standard 802.11 due to an advanced intelligent antenna system. These intelligent antennas, according to NETGEAR, continuously scan your home or office and automatically sense obstacles and electronic interference. The antennas, according to NETGEAR, dynamically adjust the wireless signal to compensate and maintain a clear connection.

23. In early February 2008, and following discovery of the pending release of the WPN 824v3 via the FCC OET Laboratory Division, William Kish—the co-founder and Chief Technology Officer of RUCKUS—conferred with Patrick Rada—the Senior Principal Wireless Engineer for NETGEAR—concerning the WPN 824v3. During that discussion, William Kish raised concerns with Patrick Rada that the WPN 824v3 embodied certain RUCKUS intellectual property. Patrick Rada indicated to William Kish that NETGEAR was unaware of any RUCKUS patents.

24. On or about February 12, 2008, and following William Kish's discussion with Patrick Rada, Selina Lo—the President and CEO of RUCKUS—met with Patrick Lo of NETGEAR concerning the WPN 824v3. NETGEAR informed RUCKUS that NETGEAR had begun substituting retail sales of the WPN 824v2 with the WPN 824v3. Patrick Lo indicated that NETGEAR would discontinue the manufacture and sale of the WPN 824v1 and WPN 824v2 models by the end of 2008 in favor of the WPN 824v3. NETGEAR also indicated that RUCKUS would not receive any licensing royalty revenue from sales of WPN 824v3.

25. When informed by RUCKUS as to the existence of certain patents on intellectual property utilized in the WPN 824v1 and WPN 824v2 as well as the newly released WPN 824v3, NETGEAR indicated that it had undertaken no due diligence with respect to any RUCKUS patents. NETGEAR instead indicated its intent to rely upon the indemnification obligations of the

component providers of the WPN 824v3. RUCKUS is informed and believes, and thereon alleges, that RAYSPAN is one of the primary component providers with an indemnification obligation to NETGEAR.

The First NETGEAR / RAYSPAN Litigation

26. On May 5, 2008, RUCKUS filed an action against NETGEAR and RAYSPAN in the United States District Court for the Northern District of California ("NETGEAR/RAYSPAN I") alleging that RUCKUS was the "assignee of the entire right, title, and interest in 7,193,562 (the "'562 Patent") and 7,358,912 (the "'912 Patent")." NETGEAR/RAYSPAN I was assigned case number 3:08-cv-2310. Following NETGEAR's and RAYSPAN's declination to proceed before a United States magistrate, the matter was assigned to the Honorable Phyllis J. Hamilton.

27. In NETGEAR/RAYSPAN I, RUCKUS alleged that "NETGEAR makes, uses, offers to sell, and sells in the United States and imports into the United States wireless routers that infringe [the '562 and '912 Patents], including but not limited to the RangeMax WPN 824v3.

28. In NETGEAR/RAYSPAN I, RUCKUS alleged that "RAYSPAN makes, uses, offers to sell, and sells in the United States and imports into the United States components incorporated into wireless routers that infringe [the '562 and '912 Patents], including but not limited to the RangeMax WPN 824v3."

29. On July 31, 2008, counsel for the parties held an initial Rule 26(f) conference for NETGEAR/RAYSPAN I. At that conference, counsel for Defendants NETGEAR and RAYSPAN advised counsel for Plaintiff RUCKUS that the Defendants were preparing to file requests for *inter partes* reexamination of the patents-in-suit in the United States Patent and Trademark Office, and would seek to stay NETGEAR/RAYSPAN I pending completion of the reexamination proceedings.

30. On September 4, 2008, NETGEAR and RAYSPAN filed requests for *inter partes* reexamination of the '562 and '912 Patents with the United States Patent and Trademark Office.

31. On September 8, 2008, NETGEAR and RAYSPAN moved the Court in NETGEAR/RAYSPAN I for an order to stay the litigation pending the outcome of the *inter partes* re-examination of the '562 and '912 Patents.

32. On November 25, 2008, the Honorable Phyllis J. Hamilton issued an order staying NETGEAR/RAYSPAN I pending completion of the *inter partes* reexamination of the '562 and '912 Patents.

Re-Examination of the '562 Patent

33. NETGEAR and RAYSPAN's *Request for Inter Partes Reexamination Under 35 U.S.C. § 311 and 37 C.F.R. § 1.913* of the '562 Patent noted that "[a] number of prior art publications—none of which were before the Patent Office during prosecution—raise substantial new questions of patentability for all claims of the '562 patent." In the "Introduction" to the *Request for Inter Partes Reexamination Under 35 U.S.C. § 311 and 37 C.F.R. § 1.913*, NETGEAR and RAYSPAN identified eight specific references—U.S. patent number 7,064,717 to Kalunzi et al., U.S. patent number 6,531,985 to Jones, *A 2.4 GHz Polarization-Diversity Planar Printed Dipole Antenna for WLAN and Wireless Communication Applications* by Chuang et al., U.S. patent number 6,052,093 to Yao et al., U.S. patent publication number 2004-0145528 to Mukai et al., U.S. patent number 6,943,749 to Paun, U.S. patent number 6,876,836 to Lin et al., and U.S. patent number 6,104,356 to Hikuma et al. NETGEAR and RAYSPAN stated that "the prior art references cited in this Request disclose pertinent teachings that were missing from the record during prosecution of the '562 patent and [that] raise substantial new questions of patentability about claims 1-36 of the '562 patent."

34. In the "Patents and Printed Publications Presented to Show Substantial New Questions of Patentability" of the *Request for Inter Partes Reexamination Under 35 U.S.C. § 311 and 37 C.F.R. § 1.913*, NETGEAR and RAYSPAN identified the aforementioned eight references and six additional references—*Smart Antennas Based on Spatial Multiplexing of Local Elements (SMILE) for Mutual Coupling Reduction* to Frederick et al., U.S. patent number 5,767,755 to Kim et al., U.S. patent number 6,424,311 to Tsai et al., U.S. patent number 6,339,404 to Johnson et al., *The PIN Diode Circuit Designer's Handbook* to Doherty, Jr. et al., and *A Switched Radio Divider for an L-Band Mobile Satellite Radio* to Varnes et al.

35. On November 28, 2008, the United States Patent and Trademark Office issued an *Order Granting Request for Inter Partes Reexamination*. The November 28, 2008 *Order Granting Request for Inter Partes Reexamination* addressed five references, all of which had been identified by NETGEAR and RAYSPAN in their *Request for Inter Partes Reexamination Under 35 U.S.C. § 311 and 37 C.F.R. § 1.913*—U.S. patent number 7,064,717 to Kalunzi et al., U.S. patent number 6,052,093 to Yao et al., U.S. patent number 6,531,985 to Jones et al., *A 2.4 GHz Polarization-Diversity Planar Printed Dipole Antenna for WLAN and Wireless Communication Applications* by Chuang et al., and U.S. patent number 6,104,356 to Hikuma et al.

36. The November 28, 2008 *Order Granting Request for Inter Partes Reexamination* also stated that "[t]he Examiner does not agree with [NETGEAR's and RAYSPAN's] characterization of the reasons for allowance of claims 1-36." The November 28, 2008 *Order Granting Request for Inter Partes Reexamination* further stated that "the issue of whether the alleged prior art references submitted by [NETGEAR's and RAYSPAN's] present a [Substantial New Question of Patentability] will be determined according to the reasons for allowance expressly stated by the Examiner in the prosecution history of the ['562 Patent].

37. The November 28, 2008 *Order Granting Request for Inter Partes Reexamination* stated that "[i]t is <u>not</u> agreed that the consideration of Kalunzi raises a [Substantial New Question of Patentability] as to <u>claims 1-10 and 18-36</u>" (underlining in the original). The Examiner did "agree[] that consideration of Kalunzi raises a [Substantial New Question of Patentability] as to <u>claims 11-17</u> of the ['562 Patent]."

38. The November 28, 2008 *Order Granting Request for Inter Partes Reexamination* stated that "[i]t is <u>not</u> agreed that the consideration of Jones raises a [Substantial New Question of Patentability] as to <u>claims 1 and 18</u>" (underlining in the original). The Examiner further stated that "there is <u>not</u> a substantial likelihood that a reasonable examiner would consider the teachings of Jones important in deciding whether <u>claims 1-10 and 18-36</u> of the ['562 Patent] are patentable" (underlining in the original).

39. The November 28, 2008 *Order Granting Request for Inter Partes Reexamination* stated that "[i]t is <u>not</u> agreed that the consideration of Chuang raises a [Substantial New Question of

Patentability] as to claims 1-10 and 18-36" (underlining in the original). The Examiner further stated that "there is not a substantial likelihood that a reasonable examiner would consider the teachings of Chuang important in deciding whether claims 1-10 and 18-36 of the ['562 Patent] are patentable" (underlining in the original). The Examiner did find that "there is a substantial likelihood that a reasonable examiner would consider the teachings of Chuang important in deciding whether claims 11-17 of the ['562 Patent] are patentable.

40. The November 28, 2008 *Order Granting Request for Inter Partes Reexamination* stated that "[i]t is not agreed that the consideration of Hikuma raises a [Substantial New Question of Patentability] as to claims 1-10 and 18-36" (underlining in the original). The Examiner further stated that "there is not a substantial likelihood that a reasonable examiner would consider the teachings of Hikuma important in deciding whether claims 1-10 and 18-36 of the ['562 Patent] are patentable" (underlining in the original). The Examiner further stated that "[i]t is not agreed that the consideration of Hikuma raises a [Substantial New Question of Patentability] as to claims 11-17" (underlining in the original). The Examiner further stated that "there is not a substantial likelihood that a reasonable examiner would consider the teachings of Hikuma important in deciding whether claims 11-17 of the ['562 Patent] are patentable" (underlining in the original).

41. The November 28, 2008 *Order Granting Request for Inter Partes Reexamination* stated that only "claims 11-17 of the ['562 Patent] will be reexamined" (underlining in the original).

42. Accompanying the November 28, 2008 *Order Granting Request for Inter Partes Reexamination* was an *Action Closing Prosecution (37 CFR 1.949)* stating that claims 1-18 and 18-36 were *not* subject to reexamination, that claims 11-17 *were* subject to reexamination, and that claims 11-17 were confirmed as patentable. The *Action Closing Prosecution (37 CFR 1.949)* further indicated that all nine of the references identified by NETGEAR and RAYSPAN had been cited and considered in re-examination of the '562 Patent.

43. On December 17, 2008, NETGEAR and RAYSPAN filed a *Petition to Order Reexamination of Claims 1-10 and 18-36*. The *Petition to Order Reexamination of Claims 1-10 and 18-36* correctly indicated that the review "must be '*de novo*.'" The *Petition to Order Reexamination of Claims 1-10 and 18-36* specifically addressed the Kalunzi, Chuang, Hikuma, and

Yao references. NETGEAR and RAYSPAN, in addition to the arguments of counsel, submitted a declaration by Professor Michael A. Jensen, Ph.D., addressing the Kalunzi reference, the Hikuma reference, and the Yao reference and otherwise supporting the *Petition to Order Reexamination of Claims 1-10 and 18-36.*

44. On July 10, 2009, the United States Patent and Trademark Office issued a *Petition Decision Denying Request to Order (sic) Additional Claims*. Through that decision ("Petition Decision"), the United States Patent and Trademark Office denied NETGEAR's and RAYSPAN's request that reexamination of claims 1-10 and 18-36 of the '562 Patent be re-examined. The Petition Decision considered NETGEAR and RAYSPAN's arguments with respect to the Kalunzi, Chuang, Hikuma, and Yao references as well as the declaration by Professor Michael A. Jensen, Ph.D. addressing the Kalunzi reference, the Hikuma reference, and the Yao reference and otherwise supporting the *Petition to Order Reexamination of Claims 1-10 and 18-36.* As a result of the Petition Decision, further consideration of claims 1-10 and 18-36 of the present re-examination is foreclosed.

45. On August 6, 2009, NETGEAR and RAYSPAN appealed the finding of patentability of claims 11-17 of the '562 Patent. On October 5, 2009, NETGEAR and RAYSPAN filed an appeal brief addressing, specifically, the Kalunzi, Hikuma, and Chuang references.

46. RUCKUS is informed and believes, and thereon alleges, that all art that could have been identified to the United States Patent and Trademark Office by NETGEAR and RAYSPAN with respect to claims 1-10 and 18-36 has been identified to the United States Patent and Trademark Office by NETGEAR and RAYSPAN.

47. RUCKUS is informed and believes, and thereon alleges, that all issues that could have been raised before the United States Patent and Trademark Office by NETGEAR and RAYSPAN with respect to claims 1-10 and 18-36 have been raised before the United States Patent and Trademark Office by NETGEAR and RAYSPAN.

48. RUCKUS is informed and believes, and thereon alleges, that all art that could have been identified to the United States Patent and Trademark Office by NETGEAR and RAYSPAN

with respect to claims 11-17 has been identified to the United States Patent and Trademark Office by NETGEAR and RAYSPAN.

49. RUCKUS is informed and believes, and thereon alleges, that all issues that could have been raised before the United States Patent and Trademark Office by NETGEAR and RAYSPAN with respect to claims 11-17 have been raised before the United States Patent and Trademark Office by NETGEAR and RAYSPAN.

50. NETGEAR and RAYSPAN have not identified new prior art during the *inter partes* reexamination of the '562 Patent.

51. RUCKUS is informed and believes, and thereon alleges, that NETGEAR and RAYSPAN have not sought out new prior art during the *inter partes* reexamination of the '562 Patent.

52. NETGEAR and RAYSPAN will be estopped from later asserting the invalidity of any claim finally determined to be valid and patentable on any ground which the third-party requester raised or could have raised during *inter partes* reexamination of the '562 Patent in accordance with 35 U.S.C. § 315(c).

U.S. Patent No. 7,525,486

53. RUCKUS is the assignee of the entire right, title, and interest in United States Patent Numbers 7,525,486 (the "'486 Patent"). The '486 Patent issued on April 28, 2009 and is entitled "Increased Wireless Coverage Patterns." A true and correct copy of the '486 Patent is attached hereto as Exhibit A.

54. The '486 Patent is a continuation of U.S. patent application number 11/022,080. U.S. patent application number 11/022,080 is the application that eventually issued as RUCKUS' '562 Patent. The '562 Patent, as addressed above, is currently under re-examination. Reexamination of claims 1-10 and 18-36 of the '562 Patent has been twice denied by the United States Patent and Trademark Office. Reexamination of claims 11-17 of the '562 Patent has been granted by the United States Patent and Trademark Office. The United States Patent and Trademark Office has found claims 11-17 of the '562 Patent to be patentable and not requiring further amendment.

55. On May 30, 2008, the Examiner for the application that matured into the '486 Patent issued an office action rejecting all claims of that application as being anticipated by U.S. Patent Number 7,064,717 to Kalunzi et al. U.S. Patent Number 7,064,717 to Kalunzi had been identified by NETGEAR and RAYSPAN in their *Request for Inter Partes Reexamination Under 35 U.S.C. § 311 and 37 C.F.R. § 1.913* of the '562 Patent. The Examiner applied the Kalunzi reference against each and every claim of the application that matured into the '486 Patent.

56. On October 14, 2008, during prosecution of the application that matured into the '486 Patent, an *Information Disclosure Statement* was filed that identified, *inter alia*, U.S. Patent Number 5,767,755 to Kim et al., U.S. Patent Number 6,052,093 to Yao et al., U.S. Patent Number 6,104,356 to Hikuma et al., U.S. Patent Number 6,339,404 to Johnson et al., U.S. Patent Number 6,424,311 to Tsai et al., U.S. Patent Number 6,531,985 to Jones, U.S. Patent Number 6,876,836 to Lin et al., U.S. Patent Number 6,943,749 to Paun, U.S. Patent Publication Number 2004-0145528 to Mukai et al., *A 2.4 GHz Polarization-Diversity Planar Printed Dipole Antenna for WLAN and Wireless Communication Applications* by Chuang et al., *Smart Antennas Based on Spatial Multiplexing of Local Elements (SMILE) for Mutual Coupling Reduction* to Frederick et al., *The PIN Diode Circuit Designer's Handbook* to Doherty, Jr. et al., and *A Switched Radio Divider for an L-Band Mobile Satellite Radio* to Varnes et al. Each of the foregoing references had been identified by NETGEAR and RAYSPAN in their *Request for Inter Partes Reexamination Under 35 U.S.C. § 311 and 37 C.F.R. § 1.913* of the '562 Patent.

57. On November 26, 2008, the applicants for what would become the '486 Patent responded to the May 30, 2008 rejection. As a part of the November 26, 2008 response, the applicants submitted a *Declaration Under 37 C.F.R. § 1.131* that declared that the application that would become the '486 Patent to be "a continuation . . . of U.S. patent application number 11/022,080 filed December 23, 2004, which is now U.S. Patent Number 7,193,562." The applicants also declared in the *Declaration Under 37 C.F.R. § 1.131* that "U.S. Patent Number 7,193,562 is presently subject to a request for *inter partes* re-examination filed September 4, 2008 (control number 95/001,078)." The applicants also declared in the *Declaration Under 37 C.F.R. § 1.131* that the application that would become the '486 Patent was then rejected as being "anticipated by

U.S. patent number 7,064,717 to Kaluzni," which "has been identified in the aforementioned request for *inter partes* re-examination."

58. The applicants, as a part of the aforementioned *Declaration Under 37 C.F.R. § 1.131*, further declared that "the subject matter that is presently claimed in the independent claims of the" application that would mature into the '486 Patent was conceived "no later than November 10, 2004." November 10, 2004 is prior to the November 12, 2004 filing date of the Kalunzi reference.

59. Also on November 26, 2008, counsel for the applicants submitted a response that "direct[ed] the Examiner's attention to the request for *inter partes* re-examination lodged against U.S. Patent Number 7,193,562 to which the [application that would mature into the '486 Patent] claims a priority benefit." Also on November 26, 2008, counsel for the applicants submitted a response that noted "[a]ll references submitted in the request for re-examination of the '562 Patent have . . . been submitted" in the application that would mature into the '486 Patent. Counsel for the applicants also noted that because "the presently claimed invention was conceived before the filing date of Kalunzi," that "Kalunzi is not prior art against the presently claimed invention."

60. On December 24, 2008, the Examiner for the application that matured into the '486 Patent indicated that the references identified in the re-examination of the '562 Patent—U.S. Patent Number 5,767,755 to Kim et al., U.S. Patent Number 6,052,093 to Yao et al., U.S. Patent Number 6,104,356 to Hikuma et al., U.S. Patent Number 6,339,404 to Johnson et al., U.S. Patent Number 6,424,311 to Tsai et al., U.S. Patent Number 6,531,985 to Jones, U.S. Patent Number 6,876,836 to Lin et al., U.S. Patent Number 6,943,749 to Paun, U.S. Patent Publication Number 2004-0145528 to Mukai et al., *A 2.4 GHz Polarization-Diversity Planar Printed Dipole Antenna for WLAN and Wireless Communication Applications* by Chuang et al., *Smart Antennas Based on Spatial Multiplexing of Local Elements (SMILE) for Mutual Coupling Reduction* to Frederick et al., *The PIN Diode Circuit Designer's Handbook* to Doherty, Jr. et al., and *A Switched Radio Divider for an L-Band Mobile Satellite Radio* to Varnes et al.—had been "considered."

61. On January 9, 2009, the United States Patent and Trademark Office found "[c]laims 1-31 [to be] allowed" in that the "prior art of record" did not disclose one or more features set forth

in the independent claims of the application that matured into the '486 Patent. The Examiner further found the declaration submitted "on 11/26/2008 under 37 CFR 1.131 [to be] sufficient to overcome the US Patent No 7,064,717 reference" to Kalunzi.

62. The '486 Patent issued on April 28, 2009. The '486 Patent issued over all references cited in the re-examination of the '562 Patent.

DEFENDANTS' Unlawful Conduct Relating to the '486 Patent

63. On May 22, 2009, the parties filed a *Joint Status Report* in NETGEAR / RAYSPAN I.

64. In the May 22 *Joint Status Report*, RUCKUS noted that "U.S. patent application number 11/714,707, which is a direct continuation of the '562 Patent, issued as U.S. Patent Number 7,525,486." In the May 22 *Joint Status Report,* RUCKUS noted that "U.S. Patent [number] 7,525,486 issued after the United States Patent Office considered all of the references identified by the Defendants in the *inter partes* re-examination of the '562 Patent."

65. On June 17, 2009, counsel for RUCKUS sent correspondence to counsel for NETGEAR and RAYSPAN informing them of the issuance of U.S. Patent Number 7,525,486. In that correspondence, counsel for RUCKUS informed counsel for NETGEAR and RAYSPAN that "a number of claims in the '486 Patent read directly on your client's WPN824v3 RangeMax Wireless Router." Counsel for RUCKUS specifically identified claims 1-2, 5-8, 11-12, 15-28, and 31 of the '486 Patent. Counsel for RUCKUS stated that "*all* of the prior art references that were set forth in your client's Request for Reexamination of the patent asserted in pending Northern District of California action against NETGEAR and RAYSPAN were disclosed to and subsequently cited by the Examiner on the face of the '486 Patent." Counsel for RUCKUS also noted that "[t]he Examiner was also made expressly aware of the re-examination of the parent application" and that certain "references cited in the re-examination request were expressly addressed by the Examiner"; "[t]he '486 Patent issued notwithstanding the same."

66. NETGEAR and RAYSPAN did not respond to the June 17, 2009 correspondence.

67. RUCKUS is informed and believes, and thereon alleges, that NETGEAR makes, uses, offers to sell, and sells in the United States and imports into the United States wireless routers that infringe the '486 Patent, including but not limited to the RangeMax WPN 824v3.

68. NETGEAR's unlawful activities have resulted in an unjust enrichment to NETGEAR and immediate and irreparable harm to RUCKUS. If NETGEAR's unlawful activities are not immediately enjoined, NETGEAR will continue to be unjustly enriched and will continue to irreparably harm RUCKUS. RUCKUS has no adequate remedy at law.

69. RUCKUS is informed and believes, and thereon alleges, that RAYSPAN makes, uses, offers to sell, and sells in the United States and imports into the United States components incorporated into wireless routers that infringe the '486 Patent including but not limited to the RangeMax WPN 824v3.

70. RAYSPAN's unlawful activities have resulted in an unjust enrichment to RAYSPAN and immediate and irreparable harm to RUCKUS. If RAYSPAN's unlawful activities are not immediately enjoined, RAYSPAN will continue to be unjustly enriched and will continue to irreparably harm RUCKUS. RUCKUS has no adequate remedy at law.

COUNT I
Infringement of U.S. Patent No. 7,525,486 by NETGEAR and RAYSPAN

71. RUCKUS repeats and re-alleges each of the allegations set forth in paragraphs 1 through 70, as though fully set forth herein.

72. RUCKUS is informed and believes, and thereon alleges, that NETGEAR's actions in making, using, importing, selling, distribution, and offers for sale of the RangeMax 824v3 and possibly other products infringe at least claims 1-2, 5-8, 11-12, 15-28, and 31 of the '486 Patent. RUCKUS is informed and believes, and thereon alleges, that NETGEAR will continue to do so unless enjoined by the Court.

73. RUCKUS is informed and believes, and thereon alleges, that NETGEAR is actively inducing others to infringe—including but not limited to RAYSPAN—and/or committing acts of contributory infringement of one or more claims of the '486 Patent through NETGEAR's activities related to making, using, importing, distributing, offering for sale, and/or selling the RangeMax

WPN 824v3 product and possibly other infringing products in violation of 35 U.S.C. § 271(b) and 35 U.S.C. § 271(c), respectively.

74. RUCKUS has been damaged by NETGEAR's infringing conduct and NETGEAR is therefore liable to RUCKUS for actual damages suffered and any profits realized on the sale of the RangeMax WPN 824v3 product and possibly other infringing products, which are not taken into account in the computation of actual damages, as well as any statutory damages, such as treble damages. Moreover, such conduct is likely to cause substantial harm to RUCKUS, unless the Court enjoins the infringing conduct.

75. RUCKUS is informed and believes, and thereon alleges, that NETGEAR's infringement of the '486 Patent has since at least May 22, 2009, and continues to be, deliberate and willful.

76. RUCKUS is informed and believes, and thereon alleges, that RAYSPAN's actions in making, using, importing, selling, distribution, and offers for sale of certain components utilized in the RangeMax 824v3 and possibly other products infringe at least claims 1-2, 5-8, 11-12, 15-28, and 31 of the '486 Patent. RUCKUS is informed and believes, and thereon alleges, that RAYSPAN will continue to do so unless enjoined by the Court.

77. RUCKUS is informed and believes, and thereon alleges, that RAYSPAN is actively inducing others to infringe and/or committing acts of contributory infringement of one or more claims of the '486 Patent through RAYSPAN's activities related to making, using, importing, distributing, offering for sale, and/or selling components utilized in the RangeMax WPN 824v3 product and possibly other infringing products in violation of 35 U.S.C. § 271(b) and 35 U.S.C. § 271(c), respectively.

78. RUCKUS has been damaged by RAYSPAN's infringing conduct and RAYSPAN is therefore liable to RUCKUS for actual damages suffered and any profits realized on the sale of the RangeMax WPN 824v3 product and possibly other infringing products, which are not taken into account in the computation of actual damages, as well as any statutory damages, such as treble damages. Moreover, such conduct is likely to cause substantial harm to RUCKUS, unless the Court enjoins the infringing conduct.

79. RUCKUS is informed and believes, and thereon alleges, that RAYSPAN's infringement of the '486 Patent has been, and continues to be, deliberate and willful.

WHEREFORE, RUCKUS prays for relief as set forth herein.

PRAYER FOR RELIEF

WHEREFORE, RUCKUS requests entry of judgment in their favor and against the DEFENDANTS and each of them as follows:

A. On Count I, declaring that Defendants NETGEAR and RAYSPAN, and each of them, has infringed one or more claims of the '486 Patent;

B. On Count I, preliminarily and/or permanently enjoining Defendants NETGEAR and RAYSPAN, and each of them, and their officers, agents, servants, employees, and attorneys, and all persons acting in active concert or participation with them, from further infringing, contributing to, and/or inducing the infringement of the '486 Patent, in accordance with 35 U.S.C. § 283;

C. On Count I, awarding RUCKUS a reasonable royalty in an amount adequate to compensate RUCKUS for NETGEAR and RAYSPAN's infringement, in accordance with 35 U.S.C. § 154;

D. On Count I, awarding RUCKUS damages in an amount adequate to compensate RUCKUS for NETGEAR and RAYSPAN's infringement, in accordance with 35 U.S.C. § 284;

E. On Count I, increasing the damages to three times the amount found or assessed by virtue of the deliberate and willful nature of NETGEAR's infringement, in accordance with 35 U.S.C. § 284;

F. On all counts, for actual damages according to proof;

G. On all counts, for interest on all the foregoing amounts, at the legal rate, with effect from the due date for payment;

H. On all counts, awarding RUCKUS its costs of suit, including reasonable attorneys' fees; and

I. On all counts, granting such other and further relief as this Court may deem just and appropriate.

Dated: November 4, 2009

CARR & FERRELL LLP

By: ______________________
ROBERT J. YORIO (SBN 93178)
COLBY B. SPRINGER (SBN 214868)
TAM T. PHAM (SBN 229090)

Attorneys for Plaintiff
RUCKUS WIRELESS, INC.

DEMAND FOR JURY TRIAL

Plaintiffs hereby demand trial by jury of all issues so triable.

Dated: November 4, 2009

CARR & FERRELL LLP

By: ______________________
ROBERT J. YORIO (SBN 93178)
COLBY B. SPRINGER (SBN 214868)
TAM T. PHAM (SBN 229090)

Attorneys for Plaintiff
RUCKUS WIRELESS, INC.

Exhibit A

US007525486B2

(12) **United States Patent**
Shtrom et al.

(10) **Patent No.: US 7,525,486 B2**
(45) **Date of Patent: *Apr. 28, 2009**

(54) **INCREASED WIRELESS COVERAGE PATTERNS**

(75) Inventors: **Victor Shtrom**, Sunnyvale, CA (US); **Darin T. Milton**, Campbell, CA (US); **William S. Kish**, Saratoga, CA (US)

(73) Assignee: **Ruckus Wireless, Inc.**, Sunnyvale, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/714,707**

(22) Filed: **Mar. 5, 2007**

(65) **Prior Publication Data**

US 2007/0218953 A1 Sep. 20, 2007

Related U.S. Application Data

(63) Continuation of application No. 11/022,080, filed on Dec. 23, 2004, now Pat. No. 7,193,562.

(60) Provisional application No. 60/630,499, filed on Nov. 22, 2004.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/28 (2006.01)
H01Q 3/24 (2006.01)

(52) **U.S. Cl.** .... **343/700 MS**; 343/795; 343/876

(58) **Field of Classification Search** .... 343/700 MS, 343/793, 795, 846, 876; 455/168.1
See application file for complete search history.

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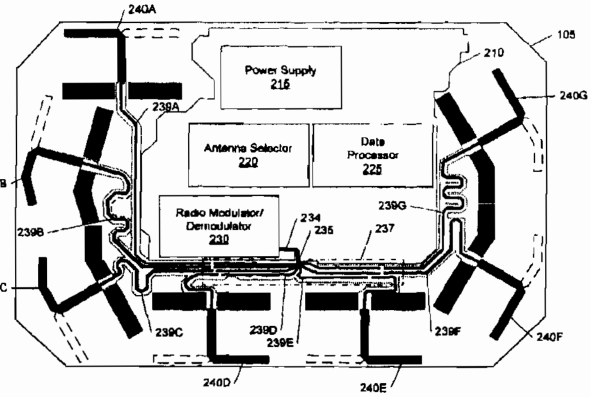
Primary Examiner—Shih-Chao Chen
(74) *Attorney, Agent, or Firm*—Carr & Ferrell LLP

(57) **ABSTRACT**

A circuit board for wireless communications includes communication circuitry for modulating and/or demodulating a radio frequency (RF) signal and an antenna apparatus for transmitting and receiving the RF signal, the antenna apparatus having selectable antenna elements located near one or more peripheries of the circuit board. A first antenna element produces a first directional radiation pattern; a second antenna element produces a second directional radiation pattern offset from the first radiation pattern. The antenna elements may include one or more reflectors configured to provide gain and broaden the frequency response of the antenna element. A switching network couples one or more of the selectable elements to the communication circuitry and provides impedance matching regardless of which or how many of the antenna elements are selected. Selecting different combinations of antenna elements results in a configurable radiation pattern; alternatively, selecting several elements may result in an omnidirectional radiation pattern.

31 Claims, 5 Drawing Sheets



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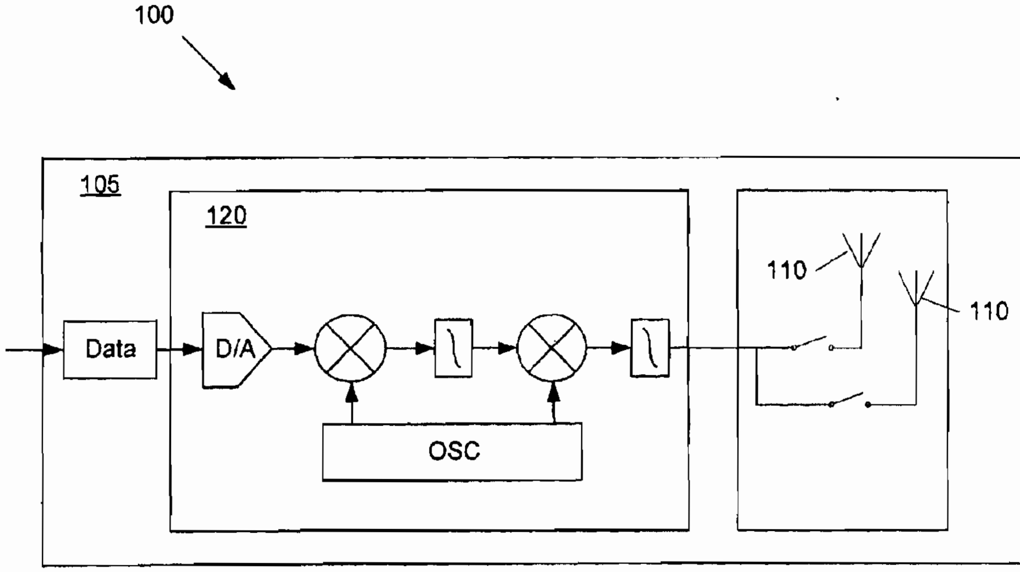

FIG. 1

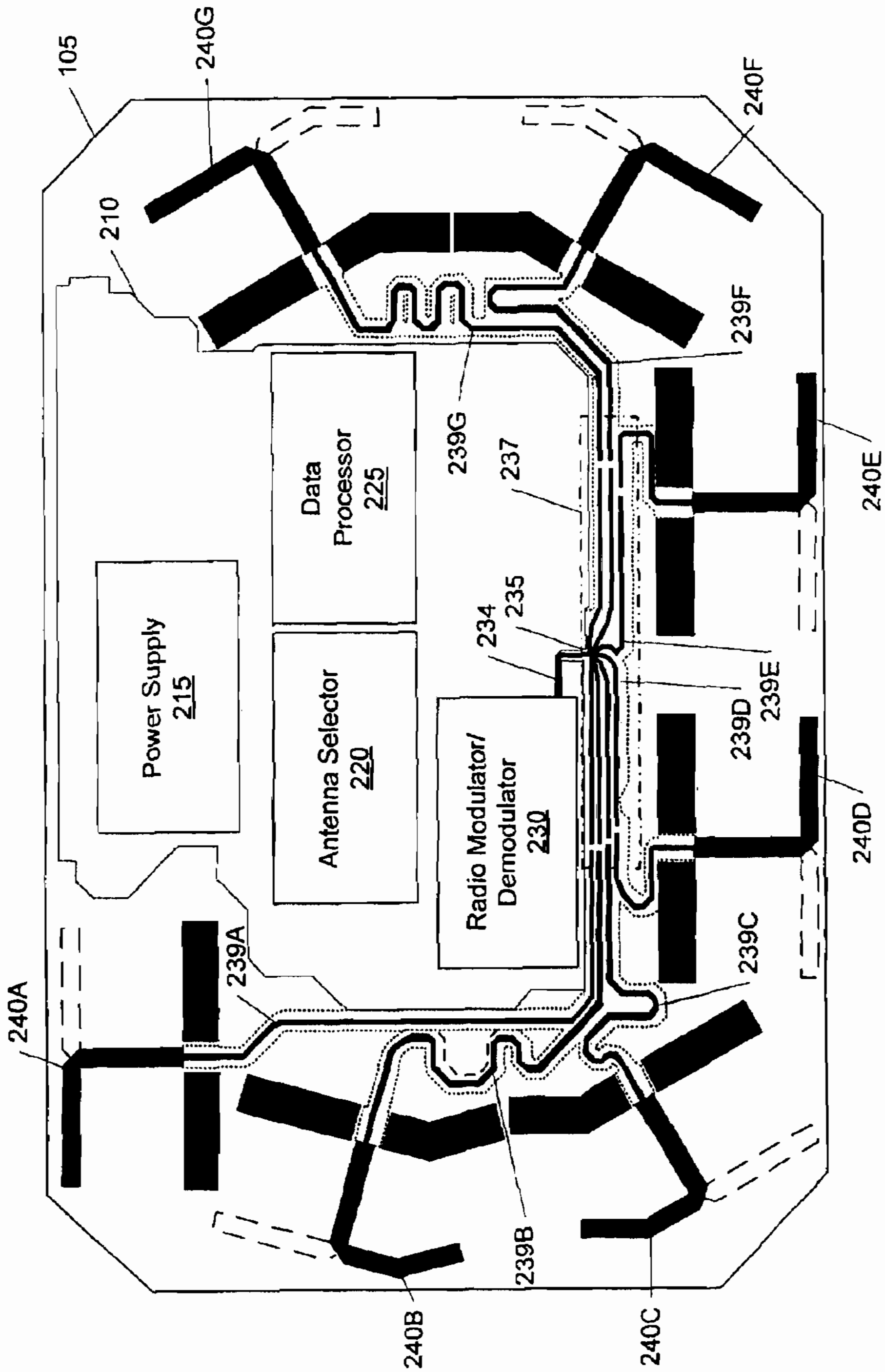
105
240G
240F
210
239F
239G
237
Data Processor 225
Power Supply 215
Antenna Selector 220
Radio Modulator/ Demodulator 230
234
235
239E
239D
240E
240D
239C
239A
240A
239B
240B
240C

FIG. 2

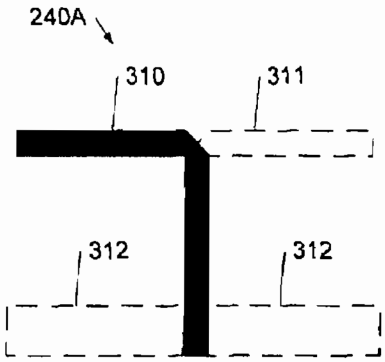

FIG. 3A

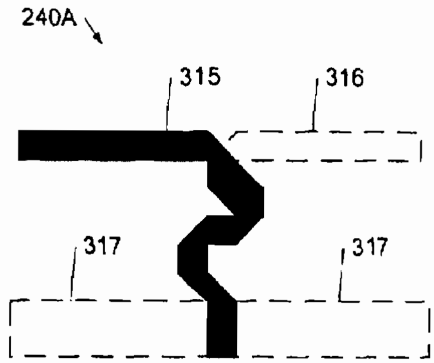

FIG. 3B

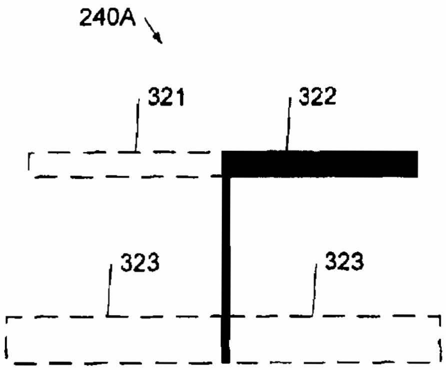

FIG. 3C

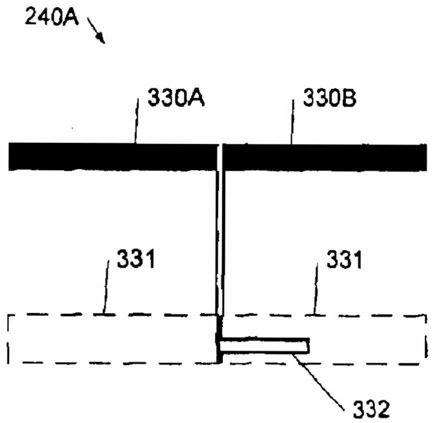

FIG. 3D

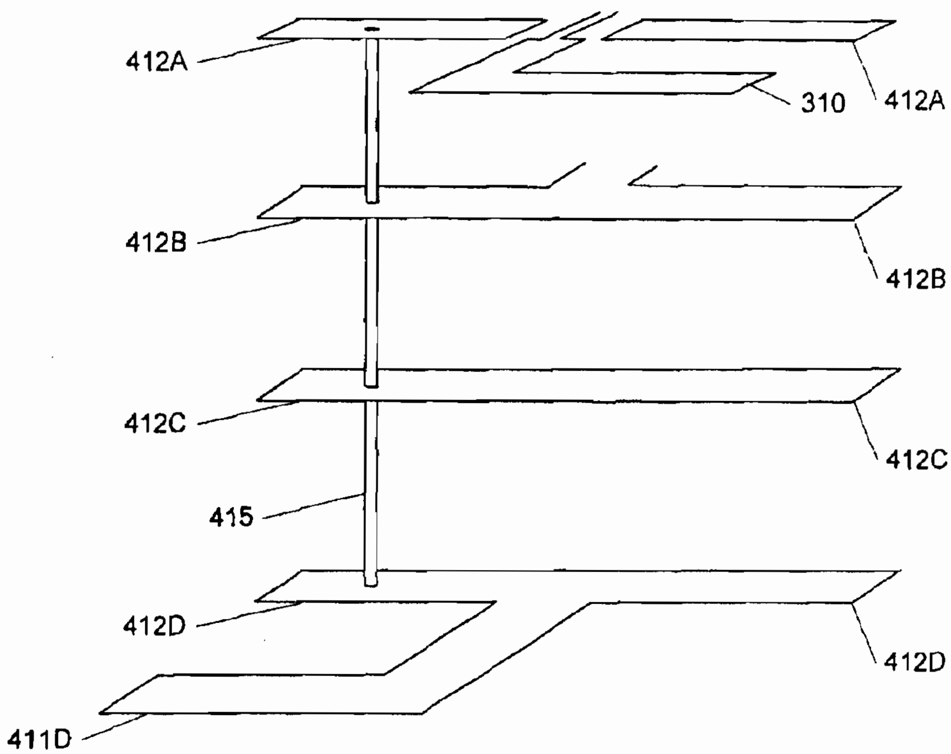

FIG. 4

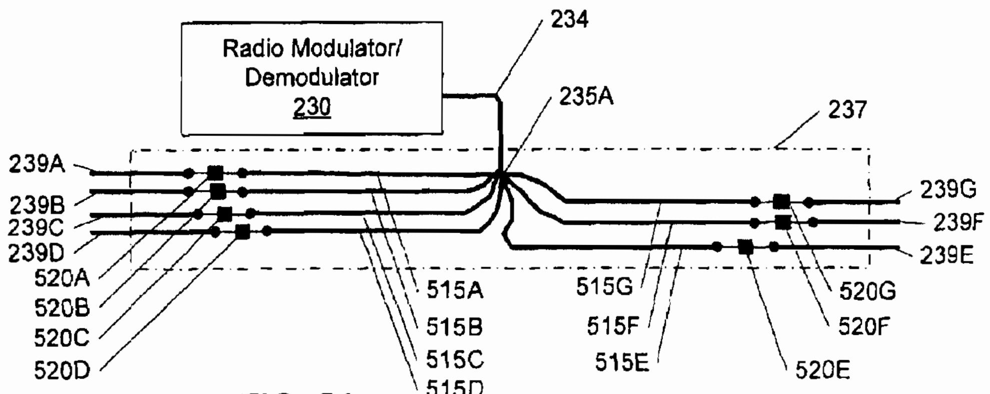

FIG. 5A

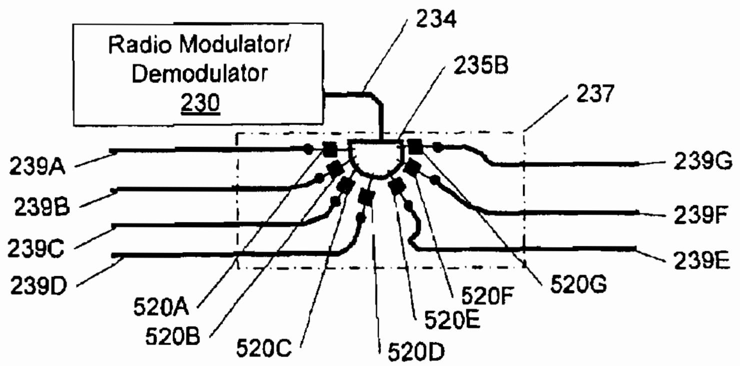

FIG. 5B

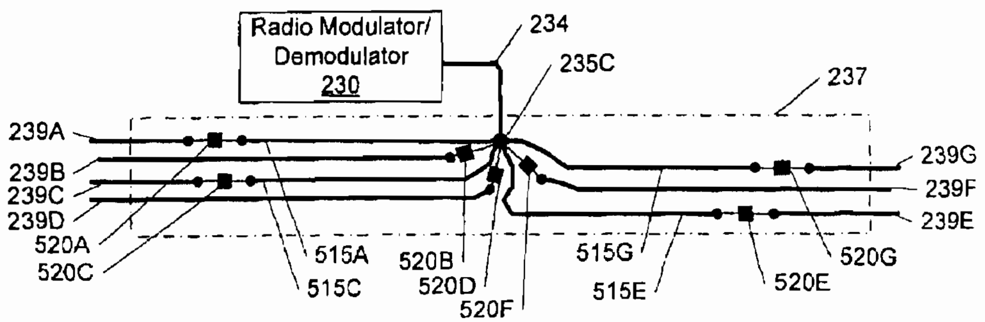

FIG. 5C

INCREASED WIRELESS COVERAGE PATTERNS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation and claims the priority benefit of U.S. patent application Ser. No. 11/022,080 filed Dec. 23, 2004 and now U.S. Pat. No. 7,193,562, which claims the priority benefit of U.S. provisional patent application No. 60/630,499 filed Nov. 22, 2004. The disclosure of each of these applications is incorporated herein by reference.

The present application is related to U.S. patent application Ser. No. 11/010,076 filed Dec. 9, 2004, which is also incorporated herein by reference.

BACKGROUND

1. Field of the Invention

The present invention relates generally to wireless communications, and more particularly to a circuit board having a peripheral antenna apparatus with selectable antenna elements.

2. Description of the Related Art

In communications systems, there is an ever-increasing demand for higher data throughput and a corresponding drive to reduce interference that can disrupt data communications. For example, in an IEEE 802.11 network, an access point (i.e., base station) communicates data with one or more remote receiving nodes (e.g., a network interface card) over a wireless link. The wireless link may be susceptible to interference from other access points, other radio transmitting devices, changes or disturbances in the wireless link environment between the access point and the remote receiving node, and so on. The interference may be such to degrade the wireless link, for example by forcing communication at a lower data rate, or may be sufficiently strong to completely disrupt the wireless link.

One solution for reducing interference in the wireless link between the access point and the remote receiving node is to provide several omnidirectional antennas for the access point, in a "diversity" scheme. For example, a common configuration for the access point comprises a data source coupled via a switching network to two or more physically separated omnidirectional antennas. The access point may select one of the omnidirectional antennas by which to maintain the wireless link. Because of the separation between the omnidirectional antennas, each antenna experiences a different signal environment, and each antenna contributes a different interference level to the wireless link. The switching network couples the data source to whichever of the omnidirectional antennas experiences the least interference in the wireless link.

However, one limitation with using two or more omnidirectional antennas for the access point is that each omnidirectional antenna comprises a separate unit of manufacture with respect to the access point, thus requiring extra manufacturing steps to include the omnidirectional antennas in the access point. A further limitation is that the omnidirectional antenna typically comprises an upright wand attached to a housing of the access point. The wand typically comprises a rod exposed outside of the housing, and may be subject to breakage or damage.

Another limitation is that typical omnidirectional antennas are vertically polarized. Vertically polarized radio frequency (RF) energy does not travel as efficiently as horizontally polarized RF energy inside a typical office or dwelling space, additionally, most laptop computer network interface cards have horizontally polarized antennas. Typical solutions for creating horizontally polarized RF antennas to date have been expensive to manufacture, or do not provide adequate RF performance to be commercially successful.

A still further limitation with the two or more omnidirectional antennas is that because the physically separated antennas may still be relatively close to each other, each of the several antennas may experience similar levels of interference and only a relatively small reduction in interference may be gained by switching from one omnidirectional antenna to another omnidirectional antenna.

SUMMARY

An exemplary embodiment of the present invention provides for an antenna array for increasing wireless coverage. The exemplary antenna array includes a radio frequency (RF) signal modulator for generating a modulated RF signal. The array also includes a series of access points arranged in a substantially circular pattern around the periphery of the antenna array. A switching network controls a modulated RF signal radiation pattern emitted by each of the access points. Each of the access points emits a directional radiation pattern offset from the directional radiation pattern of each of the other access points. The directional radiation patterns emitted by the access points collectively generate a substantially 360-degree coverage pattern.

In another exemplary embodiment of the present invention, a method for reducing interference in a wirelessly-linked communications network is provided. Through this exemplary method, antenna elements are provided at a local wireless device, the local wireless device being communicatively coupled to the wirelessly-linked communications network. The antenna elements are selectively coupled to an RF signal modulator via a switching network. A first RF-modulated signal is received from a desired remote wireless device by one of the antenna elements while a second RF-modulated signal is received at a second of the elements. The second RF-modulated signal is received from an undesired wireless source; the second RF-modulated signal causing interference with the first RF-modulated signal. The second antenna element receiving the interfering RF-modulated signal is then decoupled from the RF signal modulator by the switching network such that the receiving wireless device no longer receives the interfering signal.

A further embodiment of the present invention provides for the creation of a 360-degree wireless coverage pattern. Through this method, an RF modulated signal is generated by a radio modulator and routed to a distribution point at a wireless device; antenna elements are selectively coupled to the distribution point. Each of the antenna elements emits a directional radiation pattern. The selective coupling of the antenna elements results in the collective generation of a substantially 360-degree coverage pattern. Further, the antenna elements are configured in a circular pattern around the periphery of a circuit board in the wireless device.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described with reference to drawings that represent a preferred embodiment of the invention. In the drawings, like components have the same reference numerals. The illustrated embodiment is intended to illustrate, but not to limit the invention. The drawings include the following figures:

FIG. **1** illustrates an exemplary schematic for a system incorporating a circuit board having a peripheral antenna apparatus with selectable elements, in one embodiment in accordance with the present invention;

FIG. **2** illustrates the circuit board having the peripheral antenna apparatus with selectable elements of FIG. **1**, in one embodiment in accordance with the present invention;

FIG. **3A** illustrates a modified dipole for the antenna apparatus of FIG. **2**, in one embodiment in accordance with the present invention;

FIG. **3B** illustrates a size reduced modified dipole for the antenna apparatus of FIG. **2**, in an alternative embodiment in accordance with the present invention;

FIG. **3C** illustrates an alternative modified dipole for the antenna apparatus of FIG. **2**, in an alternative embodiment in accordance with the present invention;

FIG. **3D** illustrates a modified dipole with coplanar strip transition for the antenna apparatus of FIG. **2**, in an alternative embodiment in accordance with the present invention;

FIG. **4** illustrates the antenna element of FIG. **3A**, showing multiple layers of the circuit board, in one embodiment of the invention;

FIG. **5A** illustrates the antenna feed port and the switching network of FIG. **2**, in one embodiment in accordance with the present invention;

FIG. **5B** illustrates the antenna feed port and the switching network of FIG. **2**, in an alternative embodiment in accordance with the present invention; and

FIG. **5C** illustrates the antenna feed port and the switching network of FIG. **2**, in an alternative embodiment in accordance with the present invention.

DETAILED DESCRIPTION

A system for a wireless (i.e., radio frequency or RF) link to a remote receiving device includes a circuit board comprising communication circuitry for generating an RF signal and an antenna apparatus for transmitting and/or receiving the RF signal. The antenna apparatus includes two or more antenna elements arranged near the periphery of the circuit board. Each of the antenna elements provides a directional radiation pattern. In some embodiments, the antenna elements may be electrically selected (e.g., switched on or off) so that the antenna apparatus may form configurable radiation patterns. If multiple antenna elements are switched on, the antenna apparatus may form an omnidirectional radiation pattern.

Advantageously, the circuit board interconnects the communication circuitry and provides the antenna apparatus in one easily manufacturable printed circuit board. Including the antenna apparatus in the printed circuit board reduces the cost to manufacture the circuit board and simplifies interconnection with the communication circuitry. Further, including the antenna apparatus in the circuit board provides more consistent RF matching between the communication circuitry and the antenna elements. A further advantage is that the antenna apparatus radiates directional radiation patterns substantially in the plane of the antenna elements. When mounted horizontally, the radiation patterns are horizontally polarized, so that RF signal transmission indoors is enhanced as compared to a vertically polarized antenna.

FIG. **1** illustrates an exemplary schematic for a system **100** incorporating a circuit board having a peripheral antenna apparatus with selectable elements, in one embodiment in accordance with the present invention. The system **100** may comprise, for example without limitation, a transmitter/receiver such as an 802.11 access point, an 802.11 receiver, a set-top box, a laptop computer, a television, a cellular telephone, a cordless telephone, a wireless VoIP phone, a remote control, and a remote terminal such as a handheld gaming device. In some exemplary embodiments, the system **100** comprises an access point for communicating to one or more remote receiving nodes over a wireless link, for example in an 802.11 wireless network.

The system **100** comprises a circuit board **105** including a radio modulator/demodulator (modem) **120** and a peripheral antenna apparatus **110**. The radio modem **120** may receive data from a router connected to the Internet (not shown), convert the data into a modulated RF signal, and the antenna apparatus **110** may transmit the modulated RF signal wirelessly to one or more remote receiving nodes (not shown). The system **100** may also form a part of a wireless local area network by enabling communications among several remote receiving nodes. Although the disclosure will focus on a specific embodiment for the system **100** including the circuit board **105**, aspects of the invention are applicable to a wide variety of appliances, and are not intended to be limited to the disclosed embodiment. For example, although the system **100** may be described as transmitting to a remote receiving node via the antenna apparatus **110**, the system **100** may also receive RF-modulated data from the remote receiving node via the antenna apparatus **110**.

FIG. **2** illustrates the circuit board **105** having the peripheral antenna apparatus **110** with selectable elements of FIG. **1**, in one embodiment in accordance with the present invention. In some embodiments, the circuit board **105** comprises a printed circuit board (PCB) such as FR4, Rogers 4003, or other dielectric material with four layers, although any number of layers is comprehended, such as six.

The circuit board **105** includes an area **210** for interconnecting circuitry including for example a power supply **215**, an antenna selector **220**, a data processor **225**, and a radio modulator/demodulator (modem) **230**. In some embodiments, the data processor **225** comprises well-known circuitry for receiving data packets from a router connected to the Internet (e.g., via a local area network). The radio modem **230** comprises communication circuitry including virtually any device for converting the data packets processed by the data processor **225** into a modulated RF signal for transmission to one or more of the remote receiving nodes, and for reception therefrom. In some embodiments, the radio modem **230** comprises circuitry for converting the data packets into an 802.11 compliant modulated RF signal.

From the radio modem **230**, the circuit board **105** also includes a microstrip RF line **234** for routing the modulated RF signal to an antenna feed port **235**. Although not shown, in some embodiments, an antenna feed port **235** is configured to distribute the modulated RF signal directly to antenna elements **240A-240G** of the peripheral antenna apparatus **110** (not labeled) by way of antenna feed lines. In the embodiment depicted in FIG. **2**, the antenna feed port **235** is configured to distribute the modulated RF signal to one or more of the selectable antenna elements **240A-240G** by way of a switching network **237** and microstrip feed lines **239A-239G**. Although described as microstrip, the feed lines **239** may also comprise coupled microstrip, coplanar strips with impedance transformers, coplanar waveguide, coupled strips, and the like.

The antenna feed port **235**, the switching network **237**, and the feed lines **239** comprise switching and routing components on the circuit board **105** for routing the modulated RF signal to the antenna elements **240A-240G**. As described further herein, the antenna feed port **235**, the switching network **237**, and the feed lines **239** include structures for impedance matching between the radio modem **230** and the antenna

elements **240**. The antenna feed port **235**, the switching network **237**, and the feed lines **239** are further described with respect to FIG. **5**.

As described further herein, the peripheral antenna apparatus comprises a plurality of antenna elements **240A-240G** located near peripheral areas of the circuit board **105**. Each of the antenna elements **240** produces a directional radiation pattern with gain (as compared to an omnidirectional antenna) and with polarization substantially in the plane of the circuit board **105**. Each of the antenna elements may be arranged in an offset direction from the other antenna elements **240** so that the directional radiation pattern produced by one antenna element (e.g., the antenna element **240A**) is offset in direction from the directional radiation pattern produced by another antenna element (e.g., the antenna element **240C**). Certain antenna elements may also be arranged in substantially the same direction, such as the antenna elements **240D** and **240E**. Arranging two or more of the antenna elements **240** in the same direction provides spatial diversity between the antenna elements **240** so arranged.

In embodiments with the switching network **237**, selecting various combinations of the antenna elements **240** produces various radiation patterns ranging from highly directional to omnidirectional. Generally, enabling adjacent antenna elements **240** results in higher directionality in azimuth as compared to selecting either of the antenna elements **240** alone. For example, selecting the adjacent antenna elements **240A** and **240B** may provide higher directionality than selecting either of the antenna elements **240A** or **240B** alone. Alternatively, selecting every other antenna element (e.g., the antenna elements **240A**, **240C**, **240E**, and **240G**) or all of the antenna elements **240** may produce an omnidirectional radiation pattern.

The operating principle of the selectable antenna elements **240** may be further understood by review of co-pending U.S. patent application Ser. No. 11/010,076, entitled "System and Method for an Omnidirectional Planar Antenna Apparatus with Selectable Elements," filed Dec. 9, 2004, and previously incorporated herein by reference.

FIG. **3A** illustrates the antenna element **240A** of FIG. **2**, in one embodiment in accordance with the present invention. The antenna element **240A** of this embodiment comprises a modified dipole with components on both exterior surfaces of the circuit board **105** (considered as the plane of FIG. **3A**). Specifically, on a first surface of the circuit board **105**, the antenna element **240A** includes a first dipole component **310**. On a second surface of the circuit board **105**, depicted by dashed lines in FIG. **3**, the antenna element **240A** includes a second dipole component **311** extending substantially opposite from the first dipole component **310**. The first dipole component **310** and the second dipole component **311** form the antenna element **240A** to produce a generally cardioid directional radiation pattern substantially in the plane of the circuit board.

In some embodiments, such as the antenna elements **240B** and **240C** of FIG. **2**, the dipole component **310** and/or the dipole component **311** may be bent to conform to an edge of the circuit board **105**. Incorporating the bend in the dipole component **310** and/or the dipole component **311** may reduce the size of the circuit board **105**. Although described as being formed on the surface of the circuit board **105**, in some embodiments the dipole components **310** and **311** are formed on interior layers of the circuit board, as described herein.

The antenna element **240A** may optionally include one or more reflectors (e.g., the reflector **312**). The reflector **312** comprises elements that may be configured to concentrate the directional radiation pattern formed by the first dipole component **310** and the second dipole component **311**. The reflector **312** may also be configured to broaden the frequency response of the antenna component **240A**. In some embodiments, the reflector **312** broadens the frequency response of each modified dipole to about 300 MHz to 500 MHz. In some embodiments, the combined operational bandwidth of the antenna apparatus resulting from coupling more than one of the antenna elements **240** to the antenna feed port **235** is less than the bandwidth resulting from coupling only one of the antenna elements **240** to the antenna feed port **235**. For example, with four antenna elements **240** (e.g., the antenna elements **240A**, **240C**, **240E**, and **240G**) selected to result in an omnidirectional radiation pattern, the combined frequency response of the antenna apparatus is about 90 MHz. In some embodiments, coupling more than one of the antenna elements **240** to the antenna feed port **235** maintains a match with less than 10 dB return loss over 802.11 wireless LAN frequencies, regardless of the number of antenna elements **240** that are switched on.

FIG. **3B** illustrates the antenna element **240A** of FIG. **2**, in an alternative embodiment in accordance with the present invention. The antenna element **240A** of this embodiment may be reduced in dimension as compared to the antenna element **240A** of FIG. **3A**. Specifically, the antenna element **240A** of this embodiment comprises a first dipole component **315** incorporating a meander, a second dipole component **316** incorporating a corresponding meander, and a reflector **317**. Because of the meander, the antenna element **240A** of this embodiment may require less space on the circuit board **105** as compared to the antenna element **240A** of FIG. **3A**.

FIG. **3C** illustrates the antenna element **240A** of FIG. **2**, in an alternative embodiment in accordance with the present invention. The antenna element **240A** of this embodiment includes one or more components on one or more layers internal to the circuit board **105**. Specifically, in one embodiment, a first dipole component **321** is formed on an internal ground plane of the circuit board **105**. A second dipole component **322** is formed on an exterior surface of the circuit board **105**. As described further with respect to FIG. **4**, a reflector **323** may be formed internal to the circuit board **105**, or may be formed on the exterior surface of the circuit board **105**. An advantage of this embodiment of the antenna element **240A** is that vias through the circuit board **105** may be reduced or eliminated, making the antenna element **240A** of this embodiment less expensive to manufacture.

FIG. **3D** illustrates the antenna element **240A** of FIG. **2**, in an alternative embodiment in accordance with the present invention. The antenna element **240A** of this embodiment includes a modified dipole with a microstrip to coplanar strip (CPS) transition **332** and CPS dipole arms **330A** and **330B** on a surface layer of the circuit board **105**. Specifically, this embodiment provides that the CPS dipole arm **330A** may be coplanar with the CPS dipole arm **330B**, and may be formed on the same surface of the circuit board **105**. This embodiment may also include a reflector **331** formed on one or more interior layers of the circuit board **105** or on the opposite surface of the circuit board **105**. An advantage of this embodiment is that no vias are needed in the circuit board **105**.

It will be appreciated that the dimensions of the individual components of the antenna elements **240A-G** (e.g., the first dipole component **310**, the second dipole component **311**, and the reflector **312**) depend upon a desired operating frequency of the antenna apparatus. Furthermore, it will be appreciated that the dimensions of wavelength depend upon conductive and dielectric materials comprising the circuit board **105**, because speed of electron propagation depends upon the properties of the circuit board **105** material. There-

fore, dimensions of wavelength referred to herein are intended specifically to incorporate properties of the circuit board, including considerations such as the conductive and dielectric properties of the circuit board **105**. The dimensions of the individual components may be established by use of RF simulation software, such as IE3D from Zeland Software of Fremont, Calif.

FIG. **4** illustrates the antenna element **240**A of FIG. **3**A, showing multiple layers of the circuit board **105**, in one embodiment of the invention. The circuit board **105** of this embodiment comprises a 60 mil thick stackup with three dielectrics and four metallization layers A-D, with an internal RF ground plane at layer B (10 mils from top layer A to the internal ground layer B). Layer B is separated by a 40 mil thick dielectric to the next layer C, which may comprise a power plane. Layer C is separated by a 10 mil dielectric to the bottom layer D.

The first dipole component **310** and portions **412**A of the reflector **312** is formed on the first (exterior) surface layer A. In the second metallization layer B, which includes a connection to the ground layer (depicted as an open trace), corresponding portions **412**B of the reflector **312** are formed. On the third metallization layer C, corresponding portions **412**C of the reflector **312** are formed. The second dipole component **411**D is formed along with corresponding portions of the reflector **412**D on the fourth (exterior) surface metallization layer D. The reflectors **412**A-D and the second dipole component **411**D on the different layers are interconnected to the ground layer B by an array of metallized vias **415** (only one via **415** shown, for clarity) spaced less than 1/20th of a wavelength apart, as determined by an operating RF frequency range of 2.4-2.5 GHz for 802.11. It will be apparent to a person or ordinary skill that the reflector **312** comprises four layers, depicted as **412**A-D.

An advantage of the antenna element **240**A of FIG. **4** is that transitions in the RF path are avoided. Further, because of the cutaway portion of the reflector **412**A and the array of vias interconnecting the layers of the circuit board **105**, the antenna element **240**A of this embodiment offers a good ground plane for the ground dipole **311** and the reflector element **312**.

FIG. **5**A illustrates the antenna feed port **235** and the switching network **237** of FIG. **2**, in one embodiment in accordance with the present invention. The antenna feed port **235** of this embodiment receives the RF line **234** from the radio modem **230** into a distribution point **235**A. From the distribution point **235**A, impedance matched RF traces **515**A-G extend to PIN diodes **520**A-G. In one embodiment, the RF traces **515**A-G comprise 20 mils wide traces, based upon a 10 mil dielectric from the internal ground layer (e.g., the ground layer B of FIG. **4**). Feed lines **239**A-G (only portions of the feed lines **239** are shown for clarity) extend from the PIN diodes **520**A-G to each of the antenna elements **240**.

Each PIN diode **520** comprises a single-pole single-throw switch to switch each antenna element **240** either on or off (i.e., couple or decouple each of the antenna elements **240** to the antenna feed port **235**). In one embodiment, a series of control signals (not shown) is used to bias each PIN diode **520**. With the PIN diode **520** forward biased and conducting a DC current, the PIN diode **520** is switched on, and the corresponding antenna element **240** is selected. With the PIN diode **520** reverse biased, the PIN diode **520** is switched off.

In one embodiment, the RF traces **515**A-G are of length equal to a multiple of one half wavelength from the antenna feed port **235**. Although depicted as equal length in FIG. **5**A, the RF traces **515**A-G may be unequal in length, but multiples of one half wavelength from the antenna feed port **235**. For example, the RF trace **515**A may be of zero length so that the PIN diode **520**A is directly attached to the antenna feed port **235**. The RF trace **515**B may be one half wavelength, the RF trace **515**C may be one wavelength, and so on, in any combination. The PIN diodes **520**A-G are multiples of one half wavelength from the antenna feed port **235** so that disabling one PIN diode (e.g. the PIN diode **520**A) does not create an RF mismatch that would cause RF reflections back to the distribution point **235**A and to other traces **515** that are enabled (e.g., the trace **515**B). In this fashion, when the PIN diode **520**A is "off," the radio modem **230** sees a high impedance on the trace **515**A, and the impedance of the trace **515**B that is "on" virtually unaffected by the PIN diode **540**A. In some embodiments, the PIN diodes **520**A-G are located at an offset from the one half wavelength distance. The offset is determined to account for stray capacitance in the distribution point **235**A and/or the PIN diodes **520**A-G.

FIG. **5**B illustrates the antenna feed port **235** and the switching network **237** of FIG. **2**, in an alternative embodiment in accordance with the present invention. The antenna feed port **235** of this embodiment receives the RF line **234** from the radio modem **230** into a distribution point **235**B. The distribution point **235**B of this embodiment is configured as a solder pad for the PIN diodes **520**A-G. The PIN diodes **520**A-G are soldered between the distribution point **235**B and the ends of the feed lines **239**A-G. In essence, the distribution point **235**B of this embodiment acts as a zero wavelength distance from the antenna feed port **235**. An advantage of this embodiment is that the feed lines extending from the PIN diodes **520**A-G to the antenna elements **240**A-G offer unbroken controlled impedance.

FIG. **5**C illustrates the antenna feed port and the switching network of FIG. **2**, in an alternative embodiment in accordance with the present invention. This embodiment may be considered as a combination of the embodiments depicted in FIGS. **5**A and **5**B. The PIN diodes **520**A, **520**C, **520**E, and **520**G are connected to the RF traces **515**A, **515**C, **515**E, and **515**G, respectively, in similar fashion to that described with respect to FIG. **5**A. However, the PIN diodes **520**B, **520**D, and **520**F are soldered to a distribution point **235**C and to the corresponding feed lines **239**B, **239**D, and **239**F, in similar fashion to that described with respect to FIG. **5**B.

Although the switching network **237** is described as comprising PIN diodes **520**, it will be appreciated that the switching network **237** may comprise virtually any RF switching device such as a GaAs FET, as is well known in the art. In some embodiments, the switching network **237** comprises one or more single-pole multiple-throw switches. In some embodiments, one or more light emitting diodes (not shown) are coupled to the switching network **237** or the feed lines **239** as a visual indicator of which of the antenna elements **240** is on or off. In one embodiment, a light emitting diode is placed in circuit with each PIN diode **520** so that the light emitting diode is lit when the corresponding antenna element **240** is selected.

Referring to FIG. **2**, because in some embodiments the antenna feed port **235** is not in the center of the circuit board **105**, which would make the antenna feed lines **239** of equal length and minimum loss, the lengths of the antenna feed lines **239** may not comprise equivalent lengths from the antenna feed port **235**. Unequal lengths of the antenna feed lines **239** may result in phase offsets between the antenna elements **240**. Accordingly, in some embodiments not shown in FIG. **2**, each of the feed lines **239** to the antenna elements **240** are designed to be as long as the longest of the feed lines **239**, even for antenna elements **240** that are relatively close to

the antenna feed port **235**. In some embodiments, the lengths of the feed lines **239** are designed to be a multiple of a half-wavelength offset from the longest of the feed lines **239**. In still other embodiments, the lengths of the feed lines **239** which are odd multiples of one half wavelength from the other feed lines **239** incorporate a "phase-inverted" antenna element **240** to compensate. For example, referring to FIG. **2**, the antenna elements **240**C and **240**F are inverted by 180 degrees because the feed lines **239**C and **239**F are **180** degrees out of phase from the feed lines **239**A, **239**B, **239**D, **239**E, and **239**G. In an antenna element **240** that is phase inverted, the first dipole component (e.g., surface layer) replaces the second dipole component (e.g., ground layer). It will be appreciated that this provides the 180 degree phase shift in the antenna element to compensate for the 180 degree feed line phase shift.

An advantage of the system **100** (FIG. **1**) incorporating the circuit board **105** having the peripheral antenna apparatus with selectable antenna elements **240** (FIG. **2**) is that the antenna elements **240** are constructed directly on the circuit board **105**, therefore the entire circuit board **105** can be easily manufactured at low cost. As depicted in FIG. **2**, one embodiment or layout of the circuit board **105** comprises a substantially square or rectangular shape, so that the circuit board **105** is easily panelized from readily available circuit board material. As compared to a system incorporating externally-mounted vertically polarized "whip" antennas for diversity, the circuit board **105** minimizes or eliminates the possibility of damage to the antenna elements **240**.

A further advantage of the circuit board **105** incorporating the peripheral antenna apparatus with selectable antenna elements **240** is that the antenna elements **240** may be configured to reduce interference in the wireless link between the system **100** and a remote receiving node. For example, the system **100** communicating over the wireless link to the remote receiving node may select a particular configuration of selected antenna elements **240** that minimizes interference over the wireless link. For example, if an interfering signal is received strongly via the antenna element **240**C, and the remote receiving node is received strongly via the antenna element **240**A, selecting only the antenna element **240**A may reduce the interfering signal as opposed to selecting the antenna element **240**C. The system **100** may select a configuration of selected antenna elements **240** corresponding to a maximum gain between the system and the remote receiving node. Alternatively, the system **100** may select a configuration of selected antenna elements **240** corresponding to less than maximal gain, but corresponding to reduced interference. Alternatively, the antenna elements **240** may be selected to form a combined omnidirectional radiation pattern.

Another advantage of the circuit board **105** is that the directional radiation pattern of the antenna elements **240** is substantially in the plane of the circuit board **105**. When the circuit board **105** is mounted horizontally, the corresponding radiation patterns of the antenna elements **240** are horizontally polarized. Horizontally polarized RF energy tends to propagate better indoors than vertically polarized RF energy. Providing horizontally polarized signals improves interference rejection (potentially, up to 20 dB) from RF sources that use commonly-available vertically polarized antennas.

The invention has been described herein in terms of several preferred embodiments. Other embodiments of the invention, including alternatives, modifications, permutations and equivalents of the embodiments described herein, will be apparent to those skilled in the art from consideration of the specification, study of the drawings, and practice of the invention. The embodiments and preferred features described above should be considered exemplary, with the invention being defined by the appended claims, which therefore include all such alternatives, modifications, permutations and equivalents as fall within the true spirit and scope of the present invention.

What is claimed is:

1. An antenna array for increasing wireless coverage, comprising:

a radio frequency (RF) signal modulator configured to generate a modulated RF signal;

a plurality of modulated RF signal emission points arranged in a substantially circular pattern around the periphery of the antenna array; and

a switching network configured to control a modulated RF signal radiation pattern emitted by each of the plurality of modulated RF signal emission points, wherein each of the plurality of modulated RF signal emission points emits a directional radiation pattern offset from the directional radiation pattern of each of the other modulated RF signal emission points, the directional radiation patterns emitted by the plurality of modulated RF signal emission points collectively generating a substantially 360-degree coverage pattern.

2. The antenna array of claim **1**, wherein the modulated RF signal includes an 802.11 compliant signal.

3. The antenna array of claim **1**, wherein the RF signal modulator is intermediately coupled to a local area network by a router.

4. The antenna array of claim **3**, wherein the local area network is further coupled to the Internet.

5. The antenna array of claim **1**, wherein the coverage pattern generated by the antenna array is communicatively coupled to a coverage pattern generated by another antenna array in a wireless local area network.

6. The antenna array of claim **5**, wherein the RF signal modulator is further configured to receive RF-modulated data from the other antenna array in the wireless local area network.

7. The antenna array of claim **1**, wherein the coverage pattern is substantially horizontally polarized.

8. A method for reducing interference in a wirelessly-linked communications network, comprising:

providing a plurality of antenna elements at a local wireless device, wherein the local wireless device is communicatively coupled to the wirelessly-linked communications network and the plurality of antenna elements are selectively coupled to a radio frequency (RF) signal modulator by a switching network;

receiving a first RF-modulated signal at one of the plurality of antenna elements provided at the local wireless device, the first RF-modulated signal having been received from a desired remote wireless device over the wirelessly-linked communications network;

receiving a second RF-modulated signal at a second of the plurality of antenna elements provided at the local wireless device, the second RF-modulated signal having been received from an undesired wireless source over the wirelessly-linked communications network, wherein the second RF-modulated signal interferes with the receipt of the first RF-modulated signal; and

decoupling the second of the plurality of antenna elements from the RF-signal modulator via the switching network, wherein the decoupling of the second of the plurality of antenna elements from the RF-signal modulator prevents the local wireless device from receiving the interfering second RF-modulated signal from the undesired wireless source.

9. The method of claim 8, wherein the interference caused by the second RF-modulated signal causes communication of the first RF-modulated signal over the wirelessly-linked communications network at a lower data rate than intended for the first RF-modulated signal.

10. The method of claim 8, wherein the interference caused by the second RF-modulated signal causes complete disruption of the first RF-modulated signal over the wirelessly-linked communications network.

11. The method of claim 8, further comprising selecting a configuration of the antenna element receiving the first RF-modulated signal to correspond to a maximum gain between the local wireless device and a desired receiving node, wherein the configuration is controlled by the switching network.

12. The method of claim 8, further comprising selecting a configuration of a second antenna element also receiving the first RF-modulated signal to form a combined omnidirectional radiation pattern with a first antenna element from one of the plurality of antenna elements receiving the first RF-modulated signal and wherein the first and second antenna elements receiving the first RF-modulated signal individually generate a directional radiation pattern.

13. The method of claim 8, wherein the undesired wireless source includes an access point.

14. The method of claim 8, wherein the undesired wireless source includes a radio transmitting device.

15. A method for creating a 360-degree wireless coverage pattern, comprising:

generating a radio frequency (RF) modulated signal at a radio modulator;

routing the RF modulated signal from the radio modulator to a distribution point at a wireless device;

selectively coupling a plurality of antenna elements to the distribution point, wherein each of the plurality of antenna elements emit a directional radiation pattern and wherein the selective coupling of the plurality of antenna elements collectively generates a substantially 360-degree coverage pattern, each of the plurality of antenna elements being configured in a circular pattern around the periphery of a circuit board in the wireless device.

16. The method of claim 15, wherein the substantially 360-degree coverage pattern is a horizontally polarized radiation pattern substantially in the plane of the circuit board in the wireless device.

17. The method of claim 15, wherein the directional radiation pattern of each of the selectively coupled plurality of antenna elements is offset from one another.

18. An antenna system, comprising:

communication circuitry located in an interior area of a circuit board, the communication circuitry configured to generate an RF signal;

a plurality of antenna elements, wherein one or more of the plurality of antenna elements are arranged proximate the edges of the circuit board, each of the one or more of the plurality of antenna elements configured to form a radiation pattern when coupled to the communication circuitry; and

a switching network configured to selectively couple one or more of the plurality of antenna elements to the communication circuitry.

19. The antenna system of claim 18, wherein the one or more of the plurality of antenna elements arranged proximate the edges of the circuit board surround the communication circuitry.

20. The antenna system of claim 18, wherein the switching network includes one or more light emitting diodes that identify which of the one or more of the plurality of antenna elements are selectively coupled to the communication circuitry.

21. The antenna system of claim 18, wherein the selective coupling of the one or more of the plurality of antenna elements to the communication circuitry collectively generates a configurable radiation pattern.

22. The antenna system of claim 21, wherein the configurable radiation pattern is substantially in the plane of the circuit board.

23. The antenna system of claim 22, wherein the configurable radiation pattern is substantially horizontal.

24. The antenna system of claim 22, wherein the configurable radiation pattern is substantially vertical.

25. The antenna system of claim 21, wherein the configurable radiation pattern is substantially omnidirectional.

26. The antenna system of claim 21, wherein the configurable radiation pattern is less directional than any one of the one or more plurality of antenna elements.

27. The antenna system of claim 21, wherein the configurable radiation pattern reduces interference in a wireless link existing with a remote receiving node when compared to interference existing in a wireless link prior to the selective coupling of the one or more of the plurality of antenna elements to the communication circuitry to generate the configurable radiation pattern.

28. The antenna system of claim 18, wherein the communication circuitry is further coupled to a data processor configured to exchange data packets with the Internet.

29. The antenna system of claim 18, wherein the switching network includes one or more p-type, intrinsic, n-type diodes.

30. The antenna system of claim 18, wherein the switching network includes one or more field effect transistors.

31. The antenna system of claim 18, wherein the switching network selectively couples one or more of the plurality of antenna elements to the communication circuitry in response to interference in a wireless link existing with a remote receiving node.

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